that the FCC's approach is both feasible and technically sound. As demonstrated in the attached report, LMDS operation in the 41 GHz band is technically comparable to such operation in the Ka band and is readily achievable from both a propagation standpoint and an equipment standpoint. Teledesic, LMDS is Feasible in the 40.5 - 42.5 GHz Band, (Jan. 25, 1995) ("LMDS Report") (attached hereto as Appendix A). As demonstrated below, the propagation characteristics of LMDS operations in the Ka band and in the 41 GHz band are similar. Thus, deployment of LMDS in the 41 GHz band rather than in the Ka band will not pose additional technical or economic burdens on LMDS operators. For LMDS systems operating in the 41 GHz band, the atmospheric attenuation due to water vapor and oxygen, and the signal attenuation caused by rain are very similar to the attenuation predicted for LMDS operations in the nearby Ka band. Teledesic's review also indicates that equipment necessary to implement LMDS at 41 GHz is comparable to that proposed to be employed for LMDS at 28 GHz. Teledesic is confident that the ingenuity of the United States and foreign equipment manufacturers will enable them to quickly produce 41 GHz LMDS equipment at costs comparable to the costs projected for 28 GHz LMDS equipment.

LMDS Operation in the 41 GHz Band is Technically Comparable to Ka Band Operation from a Propagation Standpoint. Teledesic examined the effect of propagation on LMDS if it is operated at 41 GHz rather than 28 GHz and confirmed that the proposed LMDS use of the 41 GHz band is technically comparable to a Ka band operation from a propagation standpoint. LMDS Report, at 3. Teledesic's review establishes that there is virtually no difference in the operation of LMDS in the higher frequency band. Teledesic first examined the propagation effects that vary with the frequency employed: attenuation due to gasses and attenuation due to precipitation. A comparison of attenuation caused by water vapor and gasses between LMDS operations in the Ka band and in the 41 GHz band reveal insignificant differences in propagation between the LMDS operations. See id. Atmospheric attenuation due to water vapor is approximately the same for an LMDS system operating in the 41 GHz band as with one operating in the Ka band. Id. A typical value is 0.06 dB/km. Id. Atmospheric attenuation due to oxygen is also minimal. Teledesic's study demonstrates that atmospheric attenuation due to oxygen is approximately 0.04 dB/km at 41 GHz versus 0.014 dB/km at the Ka band. Id. Even using the assumption of the principal LMDS proponent that the radius of an LMDS cell will be three miles, the increased attenuation due to water vapor and oxygen absorption at 41 GHz versus 28 GHz is an insignificant 0.14 dB. Id.

Teledesic also has examined the effect of attenuation caused by precipitation on the availability of an LMDS hub to subscriber link. Teledesic's evaluation indicates that when attenuation due to rain is taken into account, there is an insignificant difference in the availability of the LMDS hub to subscriber link at the 41 GHz band as compared to that in the Ka band. LMDS Report, at 4. CellularVision has designed its analog system based on a 99.90% hub to subscriber link availability at the Ka band using a cell with a 3 mile radius. Based on Teledesic's examination, using the same EIRP at both the Ka band and at 41 Ghz, CellularVision's hub to subscriber link availability is reduced from 99.90% in the Ka band to 99.75 % in the 41 GHz band. Id. at 4. In other words, there is only a minor 0.15% difference in availability due to rain between operation of an LMDS system with a full 3 mile radius at the two frequency bands. Since this difference is technically insignificant, it will not require any changes in CellularVision's system design and should have no practical effect on subscribers or equipment. This availability figure is above the proven commercially accepted availability standard (i.e., 99.70%) used in the direct broadcast satellite industry. Teledesic's analysis is based on a conservative set of assumptions. A different set of assumptions will establish even a higher availability percentage. CellularVision and other LMDS proponents have acknowledged that LMDS is primarily a urban service. In most environments, line-of-sight limitations, not atmospheric attenuation, will be the limiting factor in cell size determinations. Therefore, in general, LMDS systems will typically employ cells with radii smaller than 3 miles. Assuming a more realistic cell size at the 41 GHz band, such as that proposed by Video/Phone, any signal attenuation will be even less than with a 3 mile cell radius.

<u>LMDS Operation in the 41 GHz Band is Technically Comparable to Ka Band Operation from an Equipment Standpoint</u>. Teledesic also has evaluated the technical comparability of the proposed LMDS operation in the 41 GHz band, as compared to the Ka band, from the prospective of the availability and cost of LMDS equipment. <u>See</u> <u>generally</u> <u>LMDS Report</u>, at 7-11. Teledesic's review indicates that the differences in equipment required to construct and operate a 41 GHz band LMDS system as opposed to a Ka band LMDS system are inconsequential. <u>Id</u>. at 7-8.

Equipment to implement LMDS-type systems at the 41 GHz band is technically comparable to equipment necessary to operate LMDS at the Ka band. The equipment differences between a 41 GHz LMDS system and a 28 GHz LMDS system are minimal. Only the microwave components change. <u>See</u> <u>LMDS Report</u>, at 7-8. The other, much more costly, elements of the LMDS system remain the same. In the subscriber terminals, only the antenna and the low-noise block converter are different for 41 GHz as opposed to 28 GHz operation. Id. The receiver (IF and demodulator), decoder, user interface, power supply, and case are the same regardless of the band in which the system operates. Id. At the hub transmitter, the only components that are different for 41 GHz versus 28 GHz operation are the upconverter, power amplifier, and antenna. Id. The transmitters (modulators and IFs), encoders, power supplies, equipment racks, site cost, and equipment required to distribute programming to the hub are identical for both 41 GHz and 28 GHz operation. Id. Consequently, there will be little impact on the total cost to build equipment for 41 GHz LMDS service. Id. at 7.

The required equipment for implementation of LMDS depends on the type of service provided to users, the necessary technical and planning parameters, sharing criteria and licensing requirements. See LMDS Report, at 8. The differences in the implementation and equipment costs among the three LMDS systems proposed during the NRMC by CellularVision, Video/Phone and Texas Instruments are greater than the differences between implementing an LMDS system in the the two bands. Id.

Given the few items of equipment in a proposed 28 GHz band LMDS system that would need to be modified if LMDS is authorized in the 41 GHz band, a 41 GHz equipment market is likely to emerge quickly, at no additional expense. Past experience has shown that when the FCC has authorized spectrum for a new service, regardless of the spectrum selected, domestic and foreign equipment manufacturers immediately rise to the occasion to design and manufacture affordable equipment for mass consumption for the newly authorized service.

Additionally, the domestic equipment market should be able to capture the synergies existing between the LMDS-type systems already authorized and planned for operation this year in Europe, actually reducing equipment costs. Quite simply, Teledesic's review confirms that there is nothing magical about operating an LMDS system at the Ka band rather than at the 41 GHz band. LMDS equipment will be manufactured in sufficient quantities and priced for mass consumer use regardless of the spectrum authorized for the service.

III. CONCLUSION

Because of the vigorous disagreement between FSS and LMDS proponents over future use of the Ka band, the FCC has not taken any action to address the legal and technical issues before it in CC Docket No. 92-297 since the conclusion of the NRMC. The instant proceeding eliminates the need for the FCC to resolve the issues being debated over the use of the Ka band by providing it with a solution that will benefit both the FSS and LMDS proponents -- redesignating for LMDS the 41 GHz band instead of a portion of the Ka band. The beauty of this win-win approach is that the same amount of technically comparable spectrum will be available for LMDS in the 41 GHz band as LMDS advocates claim they need in the 28 GHz band under a licensing scheme that is virtually identical to the regulatory framework requested by LMDS proponents in the Ka band. Because LMDS operation in the 41 GHz band is technically comparable to LMDS use in the 28 GHz band from both a propagation and equipment standpoint, the FCC can expeditiously redesignate the 41 GHz band to LMDS and promptly begin the LMDS licensing process. Teledesic supports bifurcation of this proceeding to enable the Commission to immediately address the redesignation of the 41 GHz band for LMDS in the event the FCC will require additional time to deliberate questions involving the use of bands above 41 GHz for other new services.

Based on the foregoing, Teledesic urges the FCC to redesignate the 41 GHz band for LMDS. The solution proposed by Teledesic will best serve the public interest because it permits the FCC to accommodate both the spectrum requirements of LMDS and the FSS in separate without adversely affecting the deployment of either service.

Respectfully Submitted,

TELEDESIC CORPORATION

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Its Attorneys

January 30, 1995

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APPENDIX A

LMDS is Feasible in the 40.5 - 42.5 GHz Band

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January 25, 1995

LMDS is Feasible in the 40.5 - 42.5 GHz Band

1. Introduction and Summary

This paper investigates the feasibility of operating a Local Multipoint Distribution Service (LMDS) in the 40.5 - 42.5 GHz Band. Local Multipoint Distribution Service (LMDS) is primarily a wireless video distribution service intended to compete with wired cable service and direct broadcast satellite (DBS) service.

The initial proposal of Cellular Vision of New York, L.P. ("Suite 12") was to operate LMDS in the 28 GHz band (27.5 - 29.5 GHz). This paper shows that it is also feasible to operate LMDS in the 41 GHz band (40.5 - 42.5 GHz). It is feasible from a propagation standpoint and from an equipment standpoint.

The two potentially significant propagation effects in both the 28 GHz and the 41 GHz bands are atmospheric attenuation and rain attenuation. In Section 2 it is shown that the difference in the atmospheric attenuation between the 28 GHz and the 41 GHz bands is insignificant . Over a 3 mile link (4.8 km) the increased attenuation at 41 GHz is only 0.12 dB. The difference in rain attenuation between the 28 GHz and the 41 GHz bands also is not significant. In Section 2, it is shown that for identical hub antenna coverage, for identical transmit power, for identical cell size, and for identical subscriber antenna diameters the availability of an LMDS system operating in New York City changes from 99.9% in the 28 GHz band to 99.75% in the 41 GHz band. This is an inconsequential difference.

Section 3 shows the feasibility of an LMDS system operating in the 40.5 - 42.5 GHz band from an equipment standpoint. The implementation of LMDS and hence the required equipment depends on the type of services that are provided to the users and the system performance desired. During the 28 GHz Negotiating Rule Making Committee (NRMC) meetings, three significantly different LMDS systems were proposed by proponents. The difference in the implementation of these proposed LMDS systems at the 28 GHz band is far greater than the difference between implementation of any one LMDS system at 41 GHz rather than 28 GHz.

Section 3 demonstrates the feasibility of operating at the 41 GHz band by describing the implementation and the equipment for a video distribution system at this band that is expected to be operational in 1995. It is further shown that the costs associated with an LMDS system operating at the 41 GHz band are reasonable.

2. LMDS is Feasible in the 40.5 - 42.5 GHz Band from a Propagation Standpoint

The two potentially significant propagation effects in the 41 GHz band are atmospheric attenuation and rain attenuation. The following discussion demonstrates that the impact of these effects in the 41 GHz band is similar to that in the 28 GHz band. Thus, if LMDS is feasible in the 28 GHz band from a propagation perspective, then it is also feasible in the 41 GHz band.

Figure 2-1 shows that that the atmospheric attenuation due to water vapor is approximately the same at 41 GHz as it is at 28 GHz, a typical value is 0.06 dB/km. It also shows that the atmospheric attenuation due to oxygen is approximately 0.04 dB/km at 41 GHz versus 0.014 dB/km at 28 GHz. Over a 3 mile link (4.8 km) the increased attenuation at 41 GHz is 0.12 dB. This is an insignificant difference.

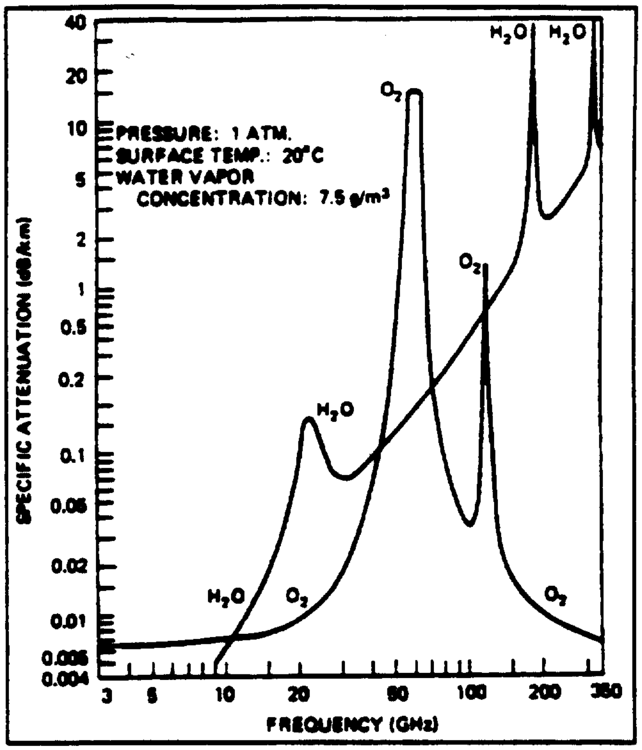


Figure 2-1. Atmospheric Attenuation by Oxygen and Water Vapor [1]

The CCIR rain model for terrestrial paths is given by [2]:

$$A = aR_{0.01}^{b}\frac{D}{1+0.045D}\times 0.12\times p^{-(0.546+0.043\log p)}$$

where

A is rain attenuation (dB)

D is the distance between transmitter and the receiver (km)

p is the percentage rain unavailability

a and b are constants depend on frequency and polarization (Figure 2-2)

$R_{0.01}$ is the rain rate in (mm/hr) corresponding to p=0.01% (Figures 2-3 and 2-4)

Suite 12 has proposed to provide 99.90% rain availability in the 28 GHz band. The CCIR model shows that for identical hub antenna coverage, for identical transmit power, for identical cell size, and for identical subscriber antenna diameters, a 41 GHz LMDS System operating in New York City provides 99.75% rain availability. This is an inconsequential difference.

Frequency (GHz)	a_H	a_V	b_H	b_V
1	0.0000387	0.0000352	0.912	0.880
2	0.000154	0.000138	0.963	0.923
3	0.000650	0.000591	1.121	1.075
6	0.00175	0.00155	1.308	1.265
7	0.00301	0.00265	1.332	1.312
8	0.00454	0.00395	1.327	1.310
10	0.0101	0.00887	1.276	1.264
12	0.0188	0.0168	1.217	1.200
15	0.0367	0.0347	1.154	1.128
20	0.0751	0.0691	1.099	1.065
25	0.124	0.113	1.061	1.030
30	0.187	0.167	1.021	1.000
35	0.263	0.233	0.979	0.963
40	0.350	0.310	0.939	0.929
45	0.442	0.393	0.903	0.897
50	0.536	0.479	0.873	0.868
60	0.707	0.642	0.826	0.824
70	0.851	0.784	0.793	0.793
80	0.975	0.906	0.769	0.769
90	1.06	0.999	9.753	0.754
100	1.12	1.06	0.743	0.744
120	1.18	1.13	0.731	0.732
150	1.31	1.27	0.710	0.711
200	1.45	1.42	0.689	0.690
300	1.36	1.35	0.688	0.689
400	1.32	1.31	0.683	0.684

Figure 2-2 CCIR Rain Attenuation Model Parameters [2]

% Time	A	B	C	D	E	F	G	H	J	K	L	M	N	P
1.0	<0.5	1	2	3	1	2	3	2	8	2	2	4	5	12
0.3	1	2	3	5	3	4	7	4	13	6	7	11	15	34
0.1	2	3	5	8	6	8	12	10	20	12	15	22	35	65
0.03	5	6	9	13	12	15	20	18	28	23	33	40	65	105
0.01	8	12	15	19	22	28	30	32	35	42	60	63	95	145
0.003	14	21	26	29	41	54	45	55	45	70	105	95	1409	200
0.001	22	32	42	42	70	78	65	83	55	100	150	120	180	250

Figure 2-3 Yearly Average Rain Rates (mm/hr) [2]

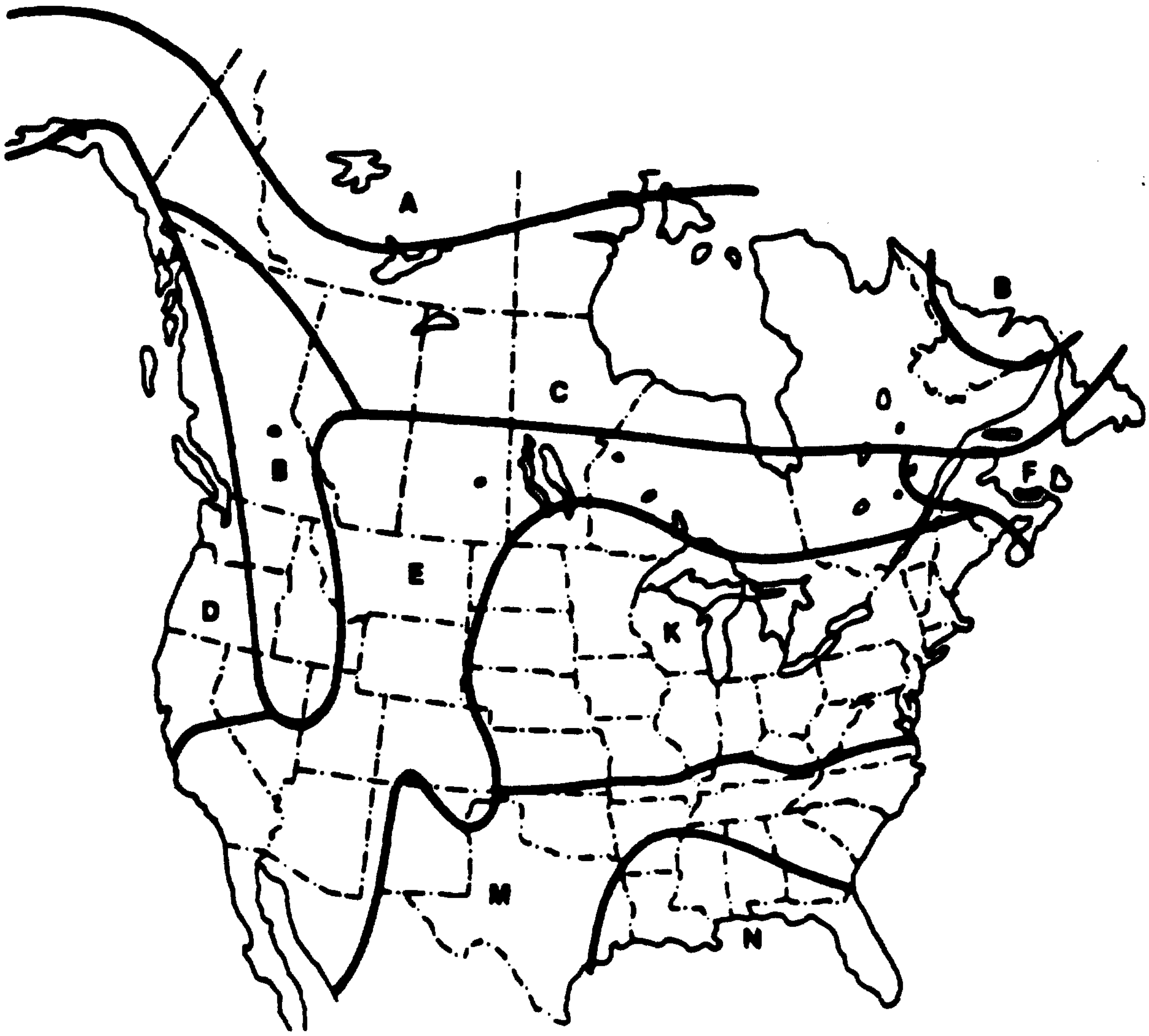
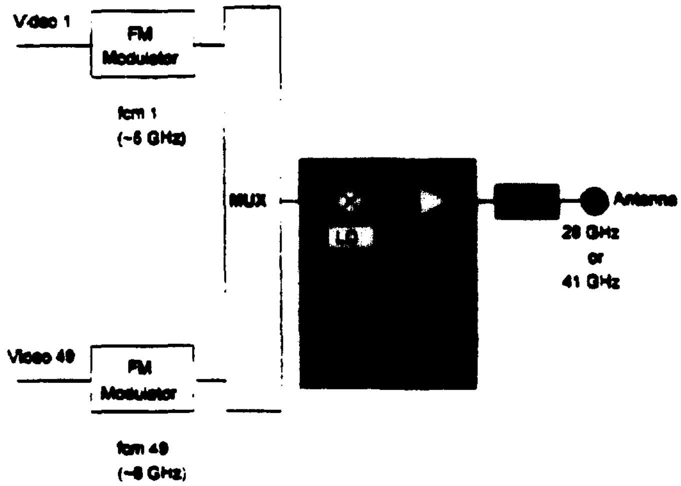


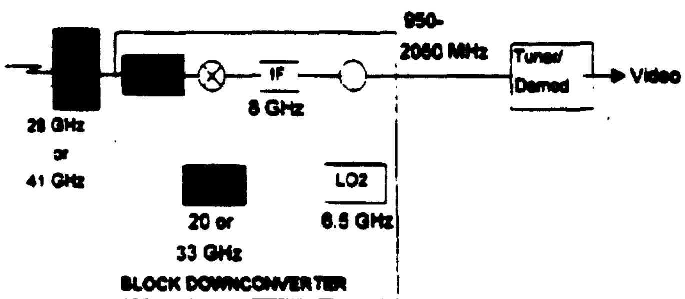
Figure 2-4: CCIR Rain Regions [2]

3. LMDS is Feasible in the 40.5 - 42.5 GHz Band from an Equipment Standpoint

The equipment differences between a 41 GHz LMDS system and a 28 GHz LMDS system are minimal. At the transmitter, the upconverter, power amplifier, and antenna are impacted. The transmitters (modulators and IF equipment), encoders, power supplies, equipment racks, site cost and equipment required to distribute programming to the hub are identical for both 41 GHz and 28 GHz operation. At the receiver, the antenna and low-noise block converter (LNB) are impacted. Thus, only the microwave components change. The other, more costly, elements of the LMDS system remain the same. Figure 3-1 shows a functional block diagram of a typical LMDS system with the impacted components identified.



TRANSMITTER



RECEIVER

Figure 3-1: Typical Implementation of LMDS Transmitter and Receiver

The implementation of LMDS and hence the required equipment depends on the type of service that is provided to the users, the necessary technical and planning parameters, sharing criteria and licensing requirements. For example, during the 28 GHz Negotiating Rule Making Committee (NRMC) meetings, three LMDS systems were proposed by its proponents. These systems are different not only in their implementation, but also in the services that they would provide to the subscribers.

Clearly the implementation of these LMDS systems are significantly different from each other. For example, the average cell size proposed by one proponent is 3 miles with an omni directional antenna at the hub to reduce the cost of system implementation whereas another proponent's design uses 1 mile reduce cells and sector antennas to increase frequency reuse and data transfer capacity. The modulation techniques proposed by the proponents also included analog techniques such as AM and FM as well as digital modulation techniques such as QPSK and QAM. In short, the differences in the implementation of the proposed LMDS systems at 28 GHz, the required equipment, and the associated cost are far greater than the differences in implementation of one LMDS system at the two different frequencies of 28 GHz and 41 GHz.

The feasibility of implementing an LMDS system in the 41 GHz band, both from technical and economic points of view, has clearly been demonstrated in the United Kingdom. The Multipoint Video Distribution System (MVDS), as it is known in the UK, is an analog system that provides an alternative to cable for the delivery of video channels. The MVDS specifications were developed by a group of regulators, operators, and semiconductor, microwave component and antenna manufacturers who met between November, 1990 and January, 1993. The result of their work was the development of transmitter and transmit antenna performance specifications which were finalized in September 1993 as MPT 1550 [3], together with a companion report [4]. The decision to use the 40.5 to 42.5 GHz Band for the delivery of video signals was made in August of 1989. Since then, the CEPT [5] has adopted this band for MVDS in order to harmonize use across Europe, with the objective of providing economies of scale in equipment cost. The first MVDS system in the UK is being developed by Eurobell and it is expected to be operational in 1995. In 1994 another working group was formed in response to the notice of interest that was sent out by the Radio Communications Agency in the UK to develop requirements and specifications for a digital interactive MVDS.

The analog MVDS uses frequency modulation for the transmission of the video signals from the hub to the subscribers. The system concept takes into account the developments within the Fixed Satellite Service where Direct To Home (DTH) services are prevalent. It exploits the maximum commonality with DTH indoor receiver units by using them as a basis for MVDS receivers. This then defines the co-polar channel spacing interleaved with cross-polar channels from the other channel groups to be used in adjacent service areas.

For system planning purposes, MVDS adopts a quality criterion of carrier to noise ratio C/N = 12 dB for 1% of the Worst Month, equivalent to 99.7% availability, to provide a "satisfactory" picture grade (CCIR impairment grade 4). This availability is the same as that used in the design of Broadcast Satellite Service at 12 GHz. Using the typical transmitter, receiver and propagation parameters at 40 GHz for these quality and availability criteria results in service range of about 4 km (2.5 miles). The equipment specifications that can provide this service quality are described briefly below.

Transmitter - There are two options which can be used for RF transmitters at 41 GHz, traveling wave tube amplifiers (TWTAs) and solid state amplifiers. The TWTA approach requires frequency division multiplexing of the RF channels before the input to the device, with sufficient back-off to reduce intermodulation effects. The output feed then simply supplies all channels to a single antenna. The solid state amplifier approach requires a single device per channel, with each output feed directly to its own antenna, rather than via a complex and lossy combiner. The whole transmitter, waveguide, and antenna can be fabricated as one module. Both approaches can easily produce RF power output of 200 mW to 1 W per channel.

Transmit Antenna - Transmit antennas suitable for use in point-to-multipoint applications necessarily have wide beamwidth. MVDS studies have determined that a sector coverage antenna of 64°, having a gain of 15 dBi, is optimum for providing an essentially circular coverage area under rain faded conditions at the desired level of availability. The selection of the antenna sector beamwidth is based on the trade off between the difficulties in manufacturing wider beamwidth sectoral horns and the fact that more elliptical coverage areas are produced by lower beamwidths.

The advantage of the sector antenna is the more effective service planning and efficient frequency reuse compared to omnidirectional antennas, taking into account the benefit to be had from geographical terrain features, transmitter site availability and azimuthal discrimination between neighboring transmitters. It is however possible to use omnidirectional antennas.

Receiver Antenna and Low Noise Down Converter - The outdoor unit of the subscriber receiver is comprised of a 40 GHz antenna and a low noise block (LNB) down converter. The MVDS specification recommends that the antenna has a gain on order of 32 dBi and is assumed to be a parabolic reflector about 150 mm (6 inches) in diameter. The pointing accuracy needs to be maintained to within 1.5 degrees. To keep costs down, the 40 GHz LNB and antenna needs to be easily mass produced. Developments in High Electron Mobility Transistor (HEMT) technology allows the use of a monolithic low noise amplifier stage before the mixer. This makes achieving receiver noise figures of 6 dB economically feasible.

Receiver Indoor Unit - The design of the receiver indoor unit does depend on the frequency of the operation of the RF link at 28 GHz or 41 GHz. In the MVDS the use of the existing Fixed Satellite Service Direct-To-Home indoor receiver units has resulted in keeping the costs down.

Link Budget - A typical 40 GHz MVDS system link budget from previously discussed parameters is shown in Table 3-1.

Table 3-1: Link Budget for MVDS

MVDS LINK BUDGET		64° Sector Coverage Antenna
Transmitter power	(dBW)	-7
Transmit antenna gain	(dBi)	15
EIRP	(dBW)	8
KTB in 26 MHz	(dBW)	-129.7
Receiver noise figure	(dB)	9
C/N required	(dB)	12
Receive antenna gain	(dBi)	32
Receiver pointing error	(dB)	-2
Minimum received level	(dBW)	-138.7
Propagation loss to service boundary	(dB)	146.7
Gaseous absorption (0.14 dB/km)	(dB)	0.6
Rain attenuation (2.22 dB/km)	(dB)	9.1
Free space path loss	(dB)	137.0
Transmission distance to service boundary	(km)	4.1

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[1] L.J., Ippolito, Jr., "Radiowave Propagation in Satellite Communications", Van Nostrand Reinhold, 1986, p. 32.

[2] L. J. Ippolito, Jr., "Propagation Effects Handbook for Satellite Systems Design", NASA Reference Publication 1082(04), Feb. 1989

[3] MPT 1550 Performance Specification for Analogue Multipoint Video Distribution Systems (MVDS) Transmitters and Transmit Antennas Operating in the Frequency Band 40.5 - 42.5 GHz. (Radiocommunication Agency).

[4] Report of the 40 GHz MVDS Working Group (Radiocommunications Agency).

[5] CEPT Recommendation T/R 52-01 E concerning the designation of a harmonised frequency band for MVDS in Europe

[6] Ian Clarke, "Microwave Video Distribution Systems - The 1994 Position," Phillips Microwave presentation to 40 GHz MVDS Working Group, 40GWG(94)16, 7 December 1994.

AFFIDAVIT OF MARK A. STURZA

I, Mark A. Sturza, being duly sworn, do depose and state as follows:

1. I am an electrical engineer specializing in Communication Systems Engineering, retained by Teledesic Corporation. Additional information concerning my engineering background and activities is shown in Attachment A hereto.

2. I prepared with Farzad Ghazvinian the Engineering Exhibit which is attached to the foregoing Comments of Teledesic Corporation in the matter of Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications. Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in the engineering exhibit are true, complete and correct to my personal knowledge.

Date: 27 [illegible] 1995

MARK A. STURZA

Subscribed and sworn before me this 27TH day of JANUARY 1995

NOTARY PUBLIC

My commission expires OCT 1, 1997

ANTHONY K. HILLS
COMM. #996361
NOTARY PUBLIC - CALIFORNIA
LOS ANGELES COUNTY
My Commission Exp. Oct. 1, 1997

The following is a supplement to the affidavit of Mark A. Sturza, 16161 Ventura Blvd. #815, Encino, CA 91436, Telephone Number (818) 907-1302.

I, Mark A. Sturza, received my BS in Applied Mathematics from the California Institute of Technology, (Pasadena, California), in 1977, my MSEE from the University of Southern California, (Los Angeles, California) in 1979, and my MBA from Pepperdine University, (Malibu, California) in 1985.

I have over 17 years of experience in the field of communications systems engineering.

From 1979 to the present I have been an independent consultant engaged in the design, development, and analysis of communications systems. My areas of specialization include: satellite communication systems, microwave radio systems, radio navigation systems, spread spectrum systems, and international and domestic regulatory support.

I was previously employed by Litton Aero Products as Director of Systems Engineering and as Director of GPS Development, by Magnavox Advanced Products and Systems Company as a Senior Engineer, and by Teledyne Systems Company as a Research Scientist.

I am a member of the Institute of Electrical and Electronics Engineers, a member of the Institute of Navigation, and a member of the American Institute of Aeronautics and Astronautics.

I have authored numerous technical papers in the areas of communications systems and of navigation systems that have been published in conference proceedings or technical journals.

I hold six U.S. patents and have several patents pending.

I have been an instructor at numerous short courses in the areas of communications systems and of radionavigation.

I have been an instructor in the School of Engineering at California State University, Northridge.

AFFIDAVIT OF FARZAD GHAZVINIAN

I, Farzad Ghazvinian, being duly sworn, do depose and state as follows:

1. I am an electrical engineer specializing in Communication Systems Engineering, retained by Teledesic Corporation. Additional information concerning my engineering background and activities is shown in Attachment A hereto.

2. I prepared with Mark A. Sturza the Engineering Exhibit which is attached to the foregoing Comments of Teledesic Corporation in the matter of Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications. Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in that engineering exhibit are true, complete and correct to my personal knowledge.

Date: 27 January 1995

FARZAD GHAZVINIAN

Subscribed and sworn before me this 27TH day of JANUARY 1995

NOTARY PUBLIC

My commission expires OCT 1, 1997

ANTHONY K. HILLS
COMM. #[illegible]
NOTARY PUBLIC - CALIFORNIA
LOS ANGELES COUNTY
My Commission Exp. Oct. 1, 1997

The following is a supplement to the affidavit of Dr. Farzad Ghazvinian, 5110 W. Goldleaf Circle, Suite 330, Los Angeles, CA 90056, Telephone Number (213) 293-3001

I, Farzad Ghazvinian, received my B.Sc. Degree in Electrical Engineering from London University (London, England) in 1975, my MSEE from University of California, Los Angeles in 1976, and my Ph.D. from University of Southern California (Los Angles, California) in 1981.

From 1981 to present, I have been employed by LinCom Corporation (Los Angeles, California) currently as Vice President and manager of Communication Systems Group.

I have supported NASA Goddard Space Flight Center on many communication system engineering efforts related to Tracking and Data Relay Satellite System (TDRSS). I have also performed many feasibility studies for advanced TDRSS concepts and applications in support of NASA space missions.

I have performed many analysis in support of NASA Johnson Space Flight Center, in connection with the design and performance evaluation of the communication systems of NASA's Space Station and Space Shuttle programs.

I have performed theoretical analysis and computer simulation to enhance the performance of ranging and synchronization systems for satellite and terrestrial networks.

I have performed feasibility study of a plan to implement a nationwide network of commercial broadcast radio stations for the purpose of emergency data communication.

I have received Public Service Group Achievement Award from NASA in recognition of my support in the development and application of Communication Link Analysis and Simulation System for NASA space programs.

I am co-author of many technical papers in the area of communication system analysis and design that has been published in conference proceedings or technical journals.

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2. " A Novel Approach to Model the Viterbi Decoded Error Sequence", Proceeding of Globecom '93, Houston, November 1993.

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TELECOSM

New low earth orbit satellites mark as decisive a break in the history of space-based communications as the PC represented in the history of computing. Pay attention to much-maligned Teledesic. Backed by Craig McCaw and Bill Gates, it is the only LEO fully focused on serving computers.

"They'll be crowding the skies."

THUS STEVEN DORFMAN, president of telecommunications and space operations for GM Hughes—the colossus of the satellite industry—warned the world of a new peril in the skies. Planning to launch 840 satellites in low earth orbits, at an altitude of some 435 miles, were a gang of cellular phone jocks and computer hackers from Seattle going under the name of Teledesic. Led by Craig McCaw and Bill Gates, they were barging onto his turf and threatening to ruin the neighborhood.

You get the image of the heavens darkening and a new Ice Age looming as more and more of this low-orbit junk—including a total of some 1,200 satellites from Motorola's Iridium, Loral-Qualcomm's Globalstar and Teledesic, among other LEO projects—accumulates in the skies. Ultimately, from this point of view, you might imagine the clutter of LEOs eclipsing the geostationary orbit itself, the so-called Clarke belt, some 21,000 miles farther out. Named after science-fiction guru Arthur C. Clarke, the geostationary orbit is the girdle and firmament of the Hughes empire.

In an article in Wireless magazine in 1945, Clarke first predicted that satellites in orbit 22,282 miles (35,860 kilometers) above the equator, where the period of revolution is 24 hours, could maintain a constant elevation and angle from any point on Earth. In such a fixed orbit, a device could remain for decades, receiving signals from a transmitter on the earth and radiating them back across continents.

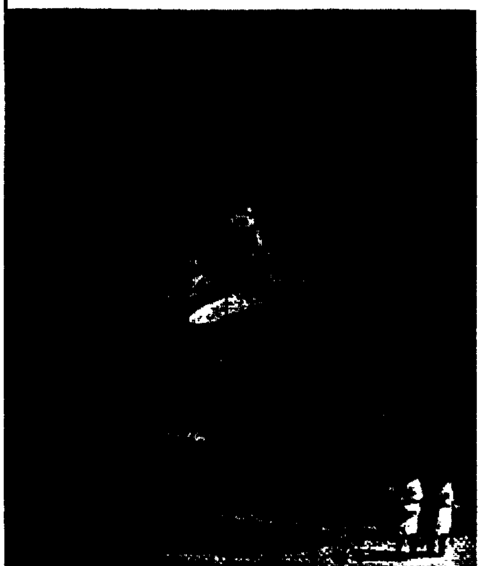
The Clarke orbit also posed a problem, however—the inverse square law for signal power. Signals in space attenuate in proportion to the square of the distance they travel. This means that communications with satellites 22,000 miles away typically require large antenna dishes (as much as 10 meters wide) or megawatts of focused beam power.

Now, however, a new satellite industry is emerging, based on gains in computer and microchip technology.

Illustrations: Chris McAllister

These advances allow the use of compact handsets with small smart antennas that can track low earth orbit satellites sweeping across the skies at a speed of 25,000 kilometers an hour at a variety of altitudes between 500 and 1,400 kilometers above the earth. Roughly 60 times nearer than geostationary satellites, LEOs find the inverse square law working in their favor, allowing them to offer far more capacity, cheaper and smaller antennas, or some combination of both. Breaking out of the Clarke orbit, these systems vastly expand the total available room for space-based communications gear.

It is indeed possible to "crowd" the Clarke belt—a relatively narrow swath at a single altitude directly above the equator. But even this swath does not become *physically* congested; collisions are no problem. The Clarke belt becomes crowded because the ability of antennas on the ground to discriminate among satellites is limited by the size of the antenna. Spaceway and Teledesic both plan to use the Ka band of frequencies, between 17 gigahertz and 30 gigahertz, or billions of cycles per second. In this band, reasonably sized antennas 66 centimeters wide can distinguish between geostationary satellites two degrees apart. That's some 800 miles in the Clarke belt. Thus no physical crowding. But it means that there are only a total of 180 Clarke slots for Ka band devices, including undesirable space over oceans.



On May 27, Dorfman summoned the upstarts, McCaw and Daggatt, to Hughes headquarters in Los Angeles for a talk. Missing was Bill Gates of Microsoft, a company that in 1993 temporarily surpassed the market value of General Motors, Hughes's owner.

LEOs, however, can be launched anywhere between the earth's atmosphere and a layer of intense radiation called the Van Allen Belt. The very concept of crowding becomes absurd in this 900-kilometer span of elevations for moving orbits that can be 500 meters apart or less. Thus the 21 proposed orbital planes of Teledesic occupy a total of 10 kilometers of altitude. At this rate, 70 or more Teledesic systems, comprising some 65,000 satellites, could comfortably fit in low earth orbits.

Nonetheless, it was clear that the LEOs, one way or another, were crowding Hughes. Hughes commands satellite systems or projects that compete with every one of the LEOs. Hughes responded to the threat of Teledesic by announcing the expansion of its Spaceway satellite system, then planned for North America alone, to cover the entire globe. Then, invoking the absolute priority currently granted geostationary systems, Hughes asked the Federal Communications Commission to block Teledesic entirely by assigning Spaceway the full five gigahertz of spectrum internationally available in the Ka band.

On May 27, Dorfman summoned the upstarts, Craig McCaw and Teledesic President Russell Daggatt, to Hughes headquarters in Los Angeles for a talk. Busy with Microsoft—the Redmond, Wash., company that in 1993 temporarily surpassed the market value of General Motors—Teledesic partner Bill Gates did not make the trip. But as the epitome of the personal computer industry, his presence haunted the scene.

Together with Spaceway chief Kevin McGrath, Dorfman set out to convince the Seattle venturers to give up their foolhardy scheme and instead join with Hughes in the nine satellites of Spaceway. Not only could Spaceway's nine satellites cover the entire globe with the same services that Teledesic's 840 satellites would provide, Spaceway could be expanded incrementally as demand emerged. Just loft another Hughes satellite. Indeed, Spaceway's ultimate system envisaged 17 satellites. With "every component proprietary to Hughes," as Dorfman said, the satellites only cost some $150 million apiece. By contrast, most of the $9 billion Teledesic system would have to be launched before global services could begin.

Nonetheless, the new LEOs marked as decisive a break in the history of space-based communications as the PC represented in the history of computing. Moreover, Teledesic would be the only LEO fully focused on serving computers—the first truly "global Internet," as McCaw's vice president Tom Alberg depicted it. It brings space communications at last into the age of ubiquitous microchip intelligence, and it brings the law of the microcosm into space communications.

If you enjoyed the New World of Wireless on the ground—with its fierce battles between communications standards, technical geniuses, giant companies, impetuous entrepreneurs and industrial politicians on three continents—you will relish the reprise hundreds and even thousands of miles up. Launching Teledesic, McCaw and